ASU Sound & Vibration Lab

معمل الصوتيات والاهتزازات

كلية الهندسة – جامعة عين شمس

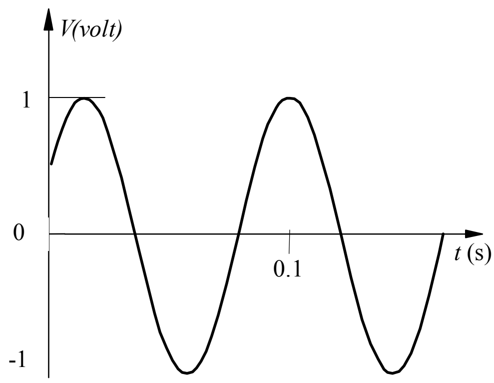
Acoustics, 3rd Year Production

2006/2007 – 2nd Semester

<u>Sheet #3</u>

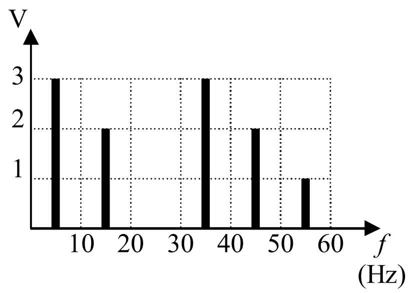
Signal Analysis and Vibration of Simple Mechanical Systems

1. A machine oscillates in simple harmonic motion and appears to be well modeled by an undamped single degree of freedom oscillation. An accelerometer gives the time response shown in the figure. If you know that the sensitivity of the accelerometer is 0.1 V/(m/s^2), what is the
   a) amplitude of the acceleration?
   b) rms value of the acceleration?
   c) period?
   d) natural frequency?
   e) amplitude of the velocity?
   f) amplitude of the displacement?



2. It is desired to do vibration measurements on an engine sitting on the deck of a boat. The measurements are disturbed by the rocking of the boat. What type of filters do you suggest?

3. The frequency response of a system is as shown in the figure. Kneatly draw the filtered response in frequency domain when subjected to each of the following filters:
   i. Low pass with cutoff frequency 30 Hz.
   ii. High pass with cutoff frequency 30 Hz.
   iii. Pass band with cutoff frequencies 30, 50 Hz.
   iv. Stop band with cutoff frequencies 10, 50 Hz.



4. Draw the time domain response of the filtered signal for the case (iv) in the previous question.

5. Speed bumps are set up in the hopes of reducing the prevailing speeds in a residential area. The idea behind the speed bumps is that the induced vibrations will be a significant irritant for the driver that continues at a speed of 15 km/h. The consultant therefore proposes a series of bumps in the road spaced at a constant interval which is tuned so as to excite the lowest vertical eigenfrequency of a car traveling at 15 km/h; see the figure below.

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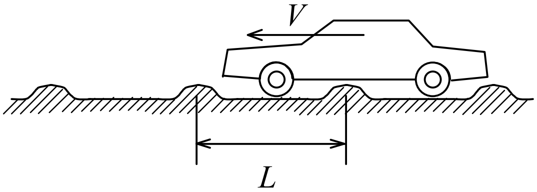
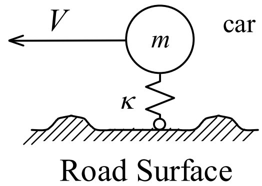


a)



b)

Assume that the car, in the simplest possible model at the relevant eigenfrequency, behaves as a rigid body coupled to the road by the four wheels. Model the car with the aid of a mass-spring system, using a so-called quarter-car model in which the mass is one-fourth of the

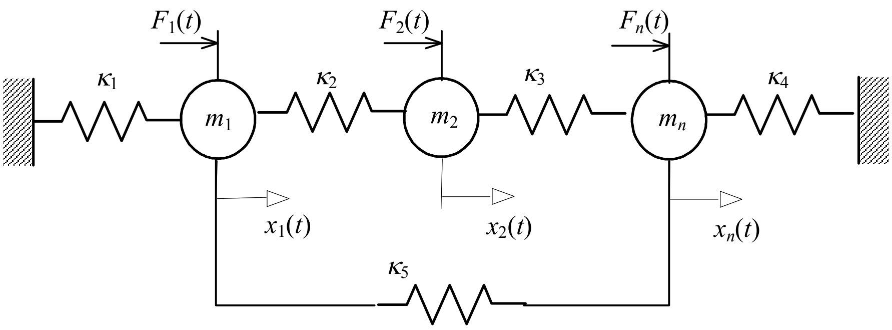
overall vehicle mass, and the spring rate corresponds that of a suspension spring. Use a mass of 250 kg and a spring rate of 3200 N/m.

a) Determine the car's lowest eigenfrequency. [Ans: 0.57 Hz]

b) What spacing L between two successive bumps should be selected in order for the lowest eigenfrequency of the car to coincide with the excitation frequency, when the car travels at a speed $V = 15$ km/h ? [Ans: 7.3 m]

6. A machine mounted on vibration isolators is modeled as a single degree-of-freedom system. The relevant parameters are estimated to be as follows: mass $m = 370$ kg, spring rate $\kappa = 2 \cdot 10^5$ N/m, damping constant $\delta = 0.2$ s^{-1}. Calculate the natural frequency of the mounted machine, and the displacement amplitude of the machine, if it is excited at that frequency by a force with a peak amplitude of 10 N. [Ans: 2.9 mm]

7. For the system shown below:



a) How many degrees of freedom does the system have?
b) Write down the equations of motion.
c) Put them in a matrix form.
d) Assuming k_1, k_2, k_3, k_4, and k_5 are respectively equal to 10, 20, 20, 10, and 20 N/mm, while the masses m_1, m_2, and m_3 are equal to 5, 10, 5 kg. Calculate the natural frequencies and draw the mode shapes of the system using the `eig` function in Matlab. [Ans: 10.5, 34.0, 42.1 Hz].
e) Which modes may cause the generation of audible sound?